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GUERRILLA WARFARE AND LAND MINE CASUALTIES REMAIN INSEPARABLE

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In 1139, the Lateran Council banned the use of the crossbow against Christians. In 1929, the Kellogg-Briand Pact outlawed war. Unfortunately, war has continued but the use of the crossbow in warfare has dropped off appreciably. Today, international efforts are underway to ban land mines in future conflict. Despite these well-meaning efforts, mines will most probably remain a constant feature of combat, particularly insurgency. Mines are cheap, easy to manufacture, easy to deploy and provide an effective counter to a modern, mechanized force. Guerrilla forces, which often operate outside the parameters and without the protection of international law, may find that the efficacy and low cost of mines outweighs their prohibition by international treaties--particularly if the guerrilla force does not represent the state and is not signatory to the treaty. Modern plastic mines may be harder to purchase in the future, but some form of mine will still benefit the guerrilla.

Countering mines increases the logistics burden on a force--from the simple need to deploy the needed mine-clearing equipment and clearing personnel to the added medical and mortuary services. Mines that wound rather than kill are more effective since every wounded mine casualty ties up many support and medical personnel. Further, mines rob a modern mechanized force of its high-speed mobility and reduce the rate of ground movement to the speed of a cautious dismounted sapper. The mere presence of mines has a marked psychological effect by introducing a further factor for reticence and caution on an already-dangerous battlefield. For these reasons, the problem of countering mines and treating mine casualties will almost certainly remain a constant for armed forces well into the next century. Just as soldiers need mine awareness training, military medical personnel need mine injury awareness training.

Mine Casualties and the Recent past

The United States Army developed an expertise in treating mine casualties during the Vietnam War. Much of this knowledge is now almost 30 years old and most of the experienced medical personnel from that era are now out of the army. Another modern force had more recent experience in treating mine casualties. Mine warfare played a

major role in the Soviet-Afghan war of 1979-1989. The Soviet 40th Army used millions of mines in Afghanistan to protect their installations and deny the Mujahideen (their guerrilla foe) use of their lines of communication (LOCs). The Mujahideen use of mines was far more limited and selective (and probably more effective tactically). Figure 1 shows Soviet 40th Army personnel deaths and vehicle losses to mines during their war in Afghanistan. As the graph shows, the Mujahideen did not have many mines at the start of the war, but soon obtained them. Soviet deaths to mines were initially quite high until the Soviets developed mine countermeasures which cut their losses. These countermeasures included issuing flak jackets, sandbagging and reinforcing vehicle floors and riding on the tops of armored vehicles. Dissemination of these countermeasures was part of the in-country courses conducted by the 45th Separate Engineer Regiment.⁽¹⁾ After that, the number of deaths from mines fell, but the number wounded by mines rose. Vehicle losses peaked in 1984 and 1985 during the heaviest fighting in the war and fell off as the Soviets prepared to withdraw.

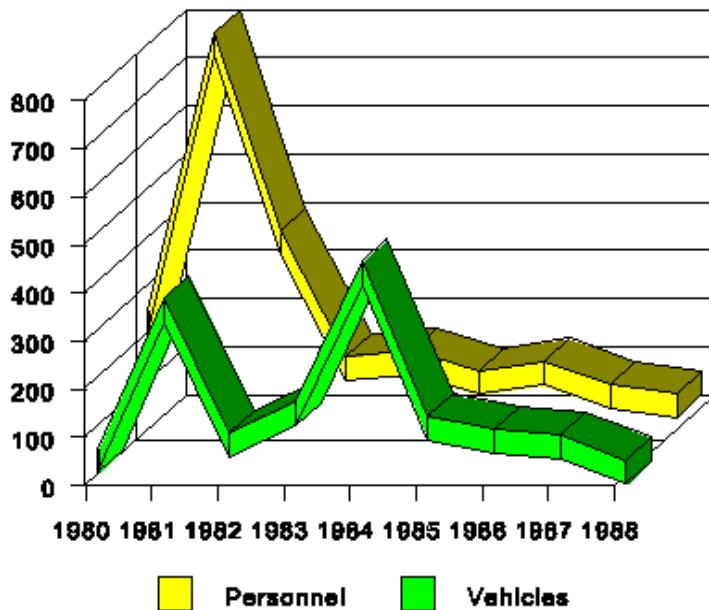


Figure 1: Soviet 40th Army losses to Mines--Personnel KIA and Vehicles Totaled ⁽²⁾

Of the 620,000 Soviet personnel who served in Afghanistan, at least 14,453 were killed or died from wounds, accidents or disease. This is 2.33% of those who served. A further 53,753 (or 8.67%) were wounded or injured.⁽³⁾ In the early part of the war, there were twice as many Soviet soldiers wounded by bullets as shrapnel, but by the end of the war, there were 2.5 times more Soviet soldiers wounded by shrapnel than by bullets. The proportion of multiple and combination wounds increased four times over the course of the war while the number of serious and critical wounds increased two times. Land mines were the primary reason for this increase in serious and critical wounds. The number of wounded from land mines increased by 25-30% over the course of the war.⁽⁴⁾ Improved Soviet medical evacuation during the war allowed more of the critically wounded to survive.⁽⁵⁾ Throughout the course of the war, land mines caused 30 to 40% of the trauma cases treated by Soviet medical personnel.⁽⁶⁾

A Nasty Piece of Work

Mines can be antitank, antivehicular or antipersonnel. Some destroy through the blast effect of the explosive charge while others rely on fragments driven by the explosive charge. They can be detonated by pressure, sound, trip-wire and remote control. Some are buried in the ground, some bound out of the ground to explode at waist-level, and others are placed on or above the ground. Mines can kill or wound nearby personnel as well as those who directly trigger the mine. Mine wounds are primarily blast and shrapnel injuries that can attack any area of the body. For those personnel who step directly on a mine, the most common injury is the loss of a lower leg, with damage to the contra lateral leg.

The land-mine casualty will probably go into shock (86.5% of Soviet mine-wounded did). In 10-15% of the patients, the shock, defined by tachycardia, hypotonia and cardiac dysrhythmias, is so severe that it is irreversible even with standard resuscitation of fluids and support. Blood pressure may fall well below tolerated level and symptoms will appear to be out of proportion to the apparent physical causes. The patient will lose lots of blood (32.6% of Soviet mine casualties required one to one-and-a-half liters [two to three units], 53.1% required up to two liters [four to five units] and 14.3% required up to three and one-half liters [seven to eight units] of blood). Due to the drop in blood pressure, massive forced infusion-transfusion therapy was necessary for these patients, but this often failed. Surgical intervention (such as amputations and surgical care of the wounds) within two or three hours of the infusion-transfusion therapy was poorly tolerated and frequently ended in death on the operating table.⁽⁷⁾

EKGs and clinical diagnosis show that heart injuries further complicate treatment of mine-injuries. EKGs disclose myocardial ischemia and resultant dysrhythmias. Autopsies disclosed that 45.6% of the Soviet mine-wounded who died in hospital had suffered some form of heart injury. The heart injuries were macroscopically classified as focal, endocardial and intramural hemorrhaging which ranged from a low blood flow to a higher blood flow from a damaged heart ventricle. Histological examination of the injured hearts revealed heart muscle fibers with no observable transverse striations and which were missing nuclei and had misshapen contours.⁽⁸⁾

Casualties with extensive lung injuries also experience profound traumatic shock. Their primary symptoms are labored breathing, cyanosis of the skin, shortness of breath, tachycardia and a drop in blood pressure. These breathing problems, particularly if they are improperly treated, often result in death. Some 20-25% of Soviet mine casualties with injured lungs developed focal pneumonia within the first hours of injury consistent with ARDS. Soviet autopsies showed that 22.8% of mine casualties had lung injuries with large areas of blood-saturated tissue. Low-focal hemorrhaging was noted throughout the lungs.⁽⁹⁾

Land-mine casualties will often suffer from a disturbance of the central nervous system. Patients that are particularly vulnerable to CNS disturbances are those who have not had proper intermediate care. The Soviet clinical picture showed that these patients would be brought into the hospital displaying the symptoms of pronounced traumatic shock. During the first hours, the patient would remain conscious and oriented in terms of time and space. Neurological examinations and a spinal tap would reveal no evidence of serious brain injury. Nevertheless, attempts to regulate the patient's hemodynamic indicators and breathing were generally not successful and the patient's brain functions would begin to worsen. The patient would lose consciousness or lapse into a deep coma.

A significant portion of these patients would die from severe disturbances to the central nervous system. Autopsies would show an ischemic softening of brain tissue with hemosaturation.⁽¹⁰⁾

The Soviets discovered that if infusion-transfusion therapy did not normalize hemodynamic indicators in land-mine injuries, this was an indicator that the patient had suffered heart injury, serious brain injury or was in early septic shock. The Soviet medical personnel learned to adjust their treatment accordingly.⁽¹¹⁾

Heart injury required a longer pre-op period than normal. The Soviet therapy involved cardiac glycocides, steroid hormones and non-narcotic analgesics. The Soviets would also administer antiplatelet aggregators and often load reducers such as dipyridamole and antispasmodics. They normalized myocardial metabolism by preparations of potassium, cocarboxylase, adenosine triphosphate [ATP] and vitamins B and C). Once the Soviets stopped the bleeding, the infusion-transfusion therapy would switch to limited amounts of fluids-chiefly gluco-insulin mixtures and gluco-vitamin cocktails. They thoroughly filtered all blood used for transfusions, particularly preserved blood.⁽¹²⁾

Soviet experience with land-mine casualties demonstrated that the usual time frames for surgical treatment of injuries did not apply. It was first essential to improve the contractile ability of the myocardium, eliminate any electrical instability of the heart and normalize the hemodynamic indicators before surgery.⁽¹³⁾

Land-mine wounds are very susceptible to septic shock resulting from extensive tissue damage and progressive wound infection. In severe septic shock, it is very difficult to stabilize the hemodynamic indicators since the vascular channels do not respond to infusion therapy and the myocardium has a pronounced depression. Soviet intensive therapy for septic shock involved administration of cardiac glycocides, a large dose of steroids and enzyme inhibitors, antibiotics, low molecular and rheologically active infusion substances and freshly heparinized blood. Once the hemodynamic indicators are stable, it was very important to prevent pulmonary edema by judicious use of diuretics.⁽¹⁴⁾ Soviet pre-op procedures for land-mine casualties with brain damage took one to two hours and involved dehydration therapy, paralysis and ventilatory support.⁽¹⁵⁾

The Soviets learned that the killer was not the patient's loss of a limb to mine blast, but rather shock and a combination of injuries to the internal organs once the bleeding was stopped. The Soviets learned that normal treatment time periods may not apply and, although emergency surgery was often necessary, it was better to make sure that the patient was stabilized before doing any surgery. The Soviets also discovered that performing multiple surgical procedures at the same time, though increasingly common under ideal circumstances, was not a good idea and should only be done by exception to save the patient's life. With land-mine injuries, surgical procedures should be done sequentially, rather than simultaneously.⁽¹⁶⁾

The Mine and the Missing Leg

Russian military medical personnel have conducted extensive research on mine injuries based on a study of war dead and wounded, experiments involving dogs and experiments involving biological dummies. Figure 2 illustrates some of their findings involving buried pressure-activated antipersonnel blast mines filled with 100 grams (3.5 ounces) of plastic explosive.⁽¹⁷⁾

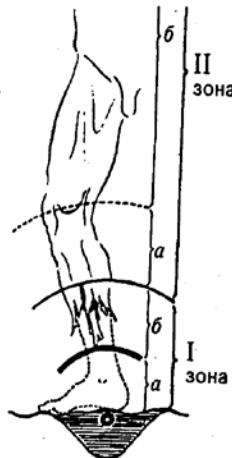


Figure 2: Zones of damage from antipersonnel mine⁽¹⁸⁾

This explosive power is sufficient to toss the victim some 30-50 centimeters (12 to 20 inches) off the ground. Zone Ia is an area of complete pulverization where all bones and other tissue are pulverized, vaporized or blown off. At the mine face, the explosion produces from 200,000-300,000 kilograms per square centimeter (2,844,600-4,266,900 pounds per square inch) of pressure. No biologic element can withstand this. Zone Ib is an area of partial destruction of tissue and is normally marked by the end of the bone. Some bone fragments, pieces of skin and blood vessel and nerve bundles that were not in the main blast path may hang past the bone. Zone IIa is an area of shock-wave injury and trauma to tissue. Zone IIb is an area of shock-wave contusion and concussion to organs and tissue.⁽¹⁹⁾

The degree of damage is a function of how far the foot was from the surface of the mine when it exploded--with direct contact being the most damaging. Zone I damage usually extends 15-20 times the radius of the mine surface.⁽²⁰⁾

Zone IIa is the area of contusions and damage resulting from the blast and subsequent gases and dust pushing against the exposed bone and fascia. Here, the blood loss is concentrated along vessels and nerve bundles. There is hemoinfiltration of the muscles which are attached to the bone and contiguous to the injured vascular fissures. The upper boundary of Zone IIa is hard to define. It may be the area of contusion of the micro-capillary system of the bone with the line drawn at the closest vascular fissure. On the other hand, the boundary could be the upper segment where the damaged muscle is still attached to the bones.⁽²¹⁾

Zone IIb begins at thigh level if the extremity has been cut off at the shin. In the thigh, there are persistent disturbances to the tone of the major vessels and their pathways and branches. There is a decline in the capability of the vessels to circulate blood. There are compound disruptions of the micro-capillary system and muscle dystrophy in these sectors of the leg. These localized circulatory disruptions are generally reversible and repairable. Higher up the patients torso, trauma to the heart and lungs and central nervous system and the brain are likely from antipersonnel mine blasts. The contusion-concussion syndrome affects these and other organs in the abdomen and chest cavity. The further the distance from the center of the blast, the less the extent of injury is a function of this distance alone. In other words, there is a physiological inequality among the various tissues and organs and they are susceptible to the effects of the blast wave to varying

degrees. For the patient's survival, the treating physician must consider the comparative physiological importance of the various organs, as well as their biological and anatomical particularities.⁽²²⁾

Contusion-concussion injuries are created by the blast wave traveling through and deforming the tissues. The effects of the deformation are cavitation, inertial resistance and cleaving. The exfoliation and cleaving injuries are caused by the waves that advance along and through tissues. These tissues have varying acoustical rigidity or firmness which is manifested by phasic shift, wave reflection and wave absorption or interference (see Table 1). The strength of the blast wave exceeds the elastic limits of the tissue and stratifies the affected tissues and tears the least-resistant tissues first. At a distance of five to ten centimeters from the blast, the periosteum and surrounding muscles are pulled from the upper third of the tibia and fibula in almost a circular pattern (see Figure 3).⁽²³⁾

Indicator	Soft tissue	Bone
Density (grams/cm ³)	1-1.2	1.93-1.98
Displacement elasticity (dynes/cm ²)	2.5×10^4	7.1×10^{10}
Resistance to tearing (dynes/cm ²)	5×10^6 - 5×10^7	9.75×10^8
Tearing index [extent] (cm)	0.2-0.7	0.05
Acoustic impedance (dynes/cm ³)	1.7×10^5	6×10^5
Speed of sound (centimeters/second)	1.5×10^5 - 1.6×10^5	3.36×10^5

Table 1: Physical Attributes of Human Tissue

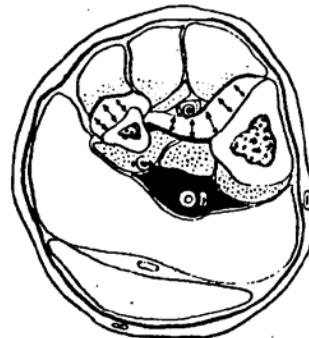


Fig. 3. Periosteum and muscle pulled from the bone by land mine blast.⁽²⁴⁾

The blood vessels develop multiple internal membrane fissures in the area 10-12 centimeters from the blast (see Figure 4).



Figure 4: Radial fissures in the interior and middle membrane of an artery from a land-mine blast⁽²⁵⁾

Peripheral nerves are damaged, and 30-40 minutes after the blast the internal layers of the myelin sheath begin to fragment and twist into a spiral. The ultra-structural destruction of the nerve pathways progress rather rapidly, with a retrograde periaxial peeling back of the myelin sheath over a period of one to three days. This demyelinization involves almost one-half of the branch nerve fibers of the sciatic nerve in the lower leg. One explanation for this phenomenon is that the cleaving damage is aided by the density of the myelin sheath which is three times greater than the surrounded neuroplasm in the axial cylinder (Figure 5).

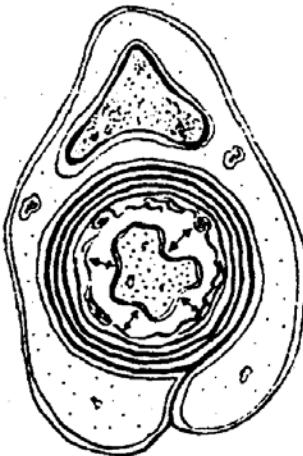


Figure 5: Demyelinization of nerve fiber from land-mine blast⁽²⁶⁾

Conclusions

Medical personnel should expect that mine warfare will continue to be a factor in future conflict, particularly counterinsurgency. The various efforts to ban land mines will probably make commercially produced land mines harder to obtain and locally manufactured land mines will take their place. These will normally be cruder, may contain more explosives and may be more damaging. This would create greater problems for the medical personnel, who are already challenged dealing with contemporary land-mine casualties.

Peace time land-mine injury training will need to practice treatment of multiple external and internal injuries. Effective treatment will require responsive medical evacuation, early stabilization and early admittance to a fully equipped hospital. Loss of a limb, extensive shrapnel injuries, shock, blood loss, respiratory difficulty, damage to multiple internal organs, sepsis and a collapse of the central nervous system are common features of mine injuries. The Soviets learned that the patient killer was not the loss of a limb to mine blast, but the shock that follows. Once the bleeding was stopped, shock and various kinds and a combination of injuries to the internal organs was far more likely to result in death. The Soviets learned that normal treatment time periods may not apply and, although emergency surgery is sometimes necessary, it is better to make sure that the patient is stabilized before doing any surgery.

In future conflicts, forward-deployed medical teams will need to deal with these immediate problems while treating the patient, and rear echelon medical facilities will

have to provide lengthy recovery, physical therapy programs and prosthetics. Soviet experience is one source that US medical personnel can use to prepare for treating land-mine casualties. As has often been observed "Good judgement comes from experience and experience comes from poor judgement".

ENDNOTES:

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7. L. N. Bisenkov and N. A. Tynyakkin, "Osobennosti okazaniya khirurgicheskoy pomoshchi postradavshim s minno-vsryvnyimi raneniyami v armii respubliki Afganistan" [Providing special surgical care to land mine casualties in the army of the Republic of Afghanistan], VMZ, January 1992, 19-20.
8. Ibid, 20.
9. Ibid.
10. Ibid.
11. Ibid, 21.

12. Ibid.

13. Ibid.

14. Ibid.

15. Ibid.

16. Ibid, 22.

17. The 100 grams represents the US M14 antipersonnel mine. It is one of the smallest antipersonnel mines and is called "the toe popper" by the troops. Soviet antipersonnel mines start at 200 grams. Most of the Soviet personnel mine casualties in Afghanistan were from the Soviet PDM mine-a small antipersonnel mine with 200 grams of plastic explosive.

18. N. F. Fomin, "Mekhanogeneticheskaya povrezhdeniya organov i tkanei minno-vzryvnykh otryvakh nizhnikh konechnostey" [The mechanical origin of damage to organs and tissue caused by land mine detonations which remove the lower extremities], VMZ, May, 1994, 13.

19. Ibid, 12-13.

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22. Ibid.

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25. Ibid.

26. Ibid, 16.
